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Metamorphosed Silurian Brachiopods from New Hampshire

Abstract: Generically identifiable Silurian brachiopods from rocks of the staurolite and sillimanite zones of regional metamorphism have been found at a number of localities in the Clough Formation of west-central New Hampshire. They include representatives of 19 brachiopod genera, 1 gastropod, 1 trilobite, and 1 pelmatozoan. The fossils occur as two faunas. The first, characterized by *Stricklandia lens* cf. *S. lens ultima*, is probably of C_4 to C_5 or C_6 age; the second, characterized by *Eocoelia hemisphaerica*, is of C_3 to C_5 age. Paleogeographically these New Hampshire fossils demonstrate that during late Llandovery time Appalachia was quite narrow, even if allowance is made for subsequent deformation. The present distance from Utica, New York (where marine beds of Clinton age occur to the west and nonmarine beds to the east), to the Connecticut River valley (where the widely distributed Clough Formation contains marine fossils of late Llandovery age) is about 140 miles. The northern and southern bounds of Appalachia are not well delimited for this time interval. The northern limit may have been an area east of Lake Temiscouata, Quebec, and the southern limit an area in northwestern Georgia. Thus Appalachia during this time is reconstructed as a narrow, elongate island or archipelago extending from Quebec to Georgia.

A brachiopod (*Howellella* sp.) from the Shaw Mountain Formation of eastern Vermont indicates an age of C_3 to early Gedinnian for that unit.

The brachiopods of Ludlow age from the type Fitch Formation of northern New Hampshire are redescribed.

CONTENTS

Introduction 1313
Acknowledgments 1314
Stratigraphy and correlation 1315
Structural and petrographic setting of the fossils 1316
Paleogeographic implications 1316
Descriptive paleontology 1319
References cited 1321
Explanation of Plates 1–10 1323

Figure
1. Principal fossil localities in the Croydon Mountain area, New Hampshire 1314
2. Silurian of the Connecticut Valley region and its relationships to the Silurian exposures of the Central Appalachians 1317

Plate Facing
1. Silurian brachiopods, Clough Formation, New Hampshire 1324
2. Silurian brachiopods, Clough and Fitch Formations, New Hampshire 1325
3. Silurian brachiopods, Clough Formation, New Hampshire 1326
4. Silurian brachiopods, Clough Formation, New Hampshire 1327
5. Silurian brachiopods, Clough Formation, New Hampshire 1328
6. Silurian brachiopods, Clough and Fitch Formations, New Hampshire 1329
7. Silurian brachiopods, Clough Formation, New Hampshire 1330
8. Silurian fossils, Clough Formation, New Hampshire 1331
9. Silurian fossils, Fitch, Clough, and Shaw Mountain Formations, New Hampshire and Vermont 1332
10. Silurian corals, Clough Formation, New Hampshire 1333

Table
1. Metamorphosed fossils from the Clough Formation of New Hampshire 1315

INTRODUCTION

The first generically identifiable, datable fossils from metamorphic rocks of the sillimanite zone were reported by Boucot and Thompson (1958, p. 362–363) from the upper part of the Clough Formation in west-central New Hampshire. Thompson has since discovered additional localities in the same region (Fig. 1), some in the staurolite zone, others in the sillimanite zone. One locality contains a fauna different from and probably slightly

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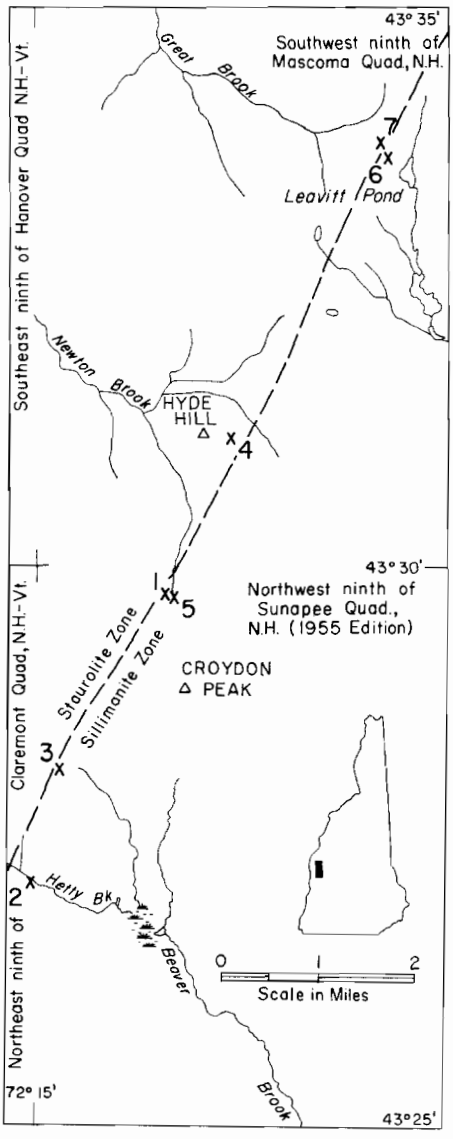

Figure 1. Principal fossil localities in the Croydon Mountain area, New Hampshire. 1. Fire road near South Branch of Newton Brook, approximate elevation 1895 feet. Corals only. Sunapee quadrangle. 2. Bed of Hetty Brook, approximate elevation 1685 feet. Claremont quadrangle. 3. Beaver Brook locality, approximate elevation 1970 feet. Sunapee quadrangle. 4. Slope east of Hyde Hill, approximate elevation 1920 feet. Not collected. Mascoma quadrangle. 5. South Branch of Newton Brook, approximate elevation 1900 feet. Pelecypods only. Sunapee quadrangle. 6. Gully west of Leavitt Pond (near Bethlehem Gneiss contact) approximate elevation 1610 feet. Mascoma quadrangle. 7. West of Leavitt Pond (north of ridge crest on old road) approximate elevation 1695 feet. Mascoma quadrangle.

older than that listed in 1958. These discoveries of generically identifiable fossils in highly metamorphosed rocks suggest that Cambrian and younger high-grade metamorphic rocks elsewhere in the world should not be dismissed from consideration as sources of fossils for dating purposes.

The description and dating of these metamorphosed Silurian fossils from the Clough Formation has necessitated re-examination of the early Ludlow fauna of the overlying Fitch Formation from northwestern New Hampshire (Billings and Cleaves, 1934). The Fitch is in the chlorite zone of metamorphism, and its fossils are consequently somewhat better preserved.

Table 1 lists metamorphosed fossils from the Clough Formation and shows where they occur.

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STRATIGRAPHY AND CORRELATION

The two faunas studied come from the upper part of the Clough Formation (Boucot and Thompson, 1958, p. 362). The presence of *Stricklandia lens* cf. *S. lens ultima* with *Paleocyclus porpita* suggests that the *Stricklandia* fauna is of C_4–C_5 age if the *Stricklandia* is correctly identified and has the same range in the Appalachians as in Britain, or of C_6 to early Wenlock age if the position of *P. porpita* in the northern Appalachians is the same as in Europe. Boucot has collected specimens of *Paleocyclus porpita* on the northeast coast of New Brunswick from La Vieille equivalents in association with *Costricklandia gaspensis:* the latter is restricted to beds of C_6 to early Wenlock age. Additional localities with recognizable sillimanite-zone specimens of *Stricklandia* have been found, although none are as richly fossiliferous as the initial find on Hetty Brook in the extreme western part of Croydon Township.

Since 1958 Thompson has found a locality on Beaver Brook in Croydon Township containing a fauna unlike that characterized by *Stricklandia* and *Paleocyclus*. This second fauna, known only from this one occurrence, is possibly slightly older than the *Stricklandia* fauna, but the absence of zonable subspecies of *Stricklandia* prevents certainty as to its exact position within the late Llandovery C_3 to C_5 or C_6 interval. The abundance of it of *Eocoelia hemisphaerica* would, in New York or Europe, indicate a C_3–C_5 correlation.

In terms of the New York section, the *Stricklandia* fauna with *Paleocyclus porpita* can best be correlated with the C_6 age zone of *Mastigobolbina typus*, which contains *Paleocyclus* (Chadwick, 1918, p. 327; Ulrich and Bassler, 1923) but not *Stricklandia*. Boucot has found *S. lens ultima* and *Microcardinalia triplesiana* in the upper half of the C_4–C_5 age Red Mountain Formation of Alabama; however, the Alabama section with *Stricklandia* contains no zonable ostracodes, so that its precise position relative to the Appalachian ostracode zones is still somewhat uncertain.

In New York terms, the *Eocoelia* fauna can-

TABLE 1. METAMORPHOSED FOSSILS FROM THE CLOUGH FORMATION OF NEW HAMPSHIRE
Localities shown on Figure 1

	(Hetty Brook) Loc. 2	(Beaver Brook) Loc. 3	Loc. 4	Loc. 5	Loc. 6	Loc. 7
"Dolerorthis" cf. *"D." flabellites*	..	x	..	..	..	..
Resserella sp.	x	x	..	..	..	..
Rhipidomelloides? sp.	..	x	..	..	..	..
Unidentified rhynchonellid	..	x	..	..	..	..
Stricklandia lens cf. *S. lens ultima*	x	..	x	..	x	x
Atrypa "reticularis"	x	x	..	..	..	..
Coelospira cf. *C. saffordi*	x	..	..	..	..	..
Eocoelia cf. *E. hemisphaerica*	..	x	..	..	..	..
Cyrtia? sp.	x	..	..	..	..	..
Eospirifer cf. *E. radiatus*	x	..	..	..	..	..
Howellella sp. 2	x	..	..	..	..	..
Meristina? sp.	..	x	..	..	..	..
Rostrospiroid?	x	..	..	..	..	..
Plectodonta sp.	x	..	..	..	..	..
Leptaena cf. *L. "rhomboidalis"*	x	..	..	..	..	..
Mesodouvillina sp.	..	x	..	..	..	..
Leptostrophia? sp.	..	x	..	..	..	..
Unidentified strophomenoids	..	x	..	..	..	..
Cornulites sp.	..	x	..	..	..	..
Trilobite fragments	x	x	..	..	..	..
Paleocyclus cf. *P. porpita*	x	..	..	..	..	..
Unidentified gastropod	x	..	..	..	..	..
Pelmatozoan columnals	..	x	..	..	..	..
Horn corals	x	..	..	..	..	..
Favositid coral	x	..	..	..	..	..
Heliolitid coral	x	..	..	..	..	x
Tryplasma? sp.	x	..	..	..	..	..
Pelecypods	..	..	..	x	..	..

not be very satisfactorily correlated. Assuming that the range of *E. hemisphaerica* is similar in both New Hampshire and New York, a Neagha to Sauquoit age (C_3–C_5) is indicated.

The *Conchidium*-bearing fauna of the Fitch Formation of northwestern New Hampshire is concluded to be of early Ludlow age because of the widespread distribution in the northern Appalachians of beds of early Ludlow age, many of which contain *Conchidium* (Boucot and Drapeau, ms. in preparation), and the absence of true *Conchidium* from beds of pre-Ludlow age. The absence of fossiliferous strata of Wenlock age in New Hampshire is notable, but the Fitch Formation of the Croydon region (unfossiliferous except for pelmatozoan debris) might be of Wenlock age since it occurs above late Llandovery age strata of the Clough.

The fauna characterized by *Stricklandia* abounds in corals, both tabulates and tetracorals (up to about 50 per cent of the total number of specimens), whereas the fauna characterized by *Eocoelia* cf. *E. hemisphaerica* has no corals and pentameroid brachiopods. This local difference in biofacies can best be explained on the basis that *E. hemisphaerica* is commonly most abundant in very arenaceous beds. The Beaver Brook beds were apparently more arenaceous than the beds containing *Stricklandia* and corals.

STRUCTURAL AND PETROGRAPHIC SETTING OF THE FOSSILS

The fossils from the Croydon Mountain area come from an outlier of the Skitchewaug nappe (Thompson, 1954; 1956). The outlier consists of parts of the inverted and upper limbs of the nappe and forms a narrow mass about 12 miles long along the ridge of Croydon Mountain in the townships of Croydon, Grantham, Plainfield, and Enfield, New Hampshire. The axial surface of the nappe has a sharply synformal shape owing to later deformation during the formation of the Croydon and Mascoma gneiss domes (Chapman, 1939; 1942; 1952; Billings, 1956). The recognizable fossils are found mainly west of the trace of the axial surface of the later fold, on the side away from the domes, and occur in both the upper and the inverted limbs of the nappe; all are probably within a mile of the hinge line where the contact between the Clough and the Fitch Formation crosses the axial surface of the nappe. It is unlikely that any of the fossil localities is more than several hundred feet from the axial surface. The axial region of the nappe is apparently a zone of minimum distortion.

The fossils in the Clough Formation occur in its uppermost part. As nearly as can be determined, none of the occurrences is stratigraphically more than a few tens of feet below the rusty-weathering quartz-mica schist which is at the base of the overlying Fitch Formation. The fossiliferous rock is apparent in the field as porous-weathering calcareous lenses a few inches to 2–3 feet thick in a nearly pure orthoquartzite. The fossils are of coarsely crystalline calcite in a matrix that may be either pure quartzite, quartz-calcite granulite, or a quartzose calc-silicate granulite containing actinolite, diopside, calcite, a light-brown garnet, and, locally, biotite. At the Hetty Brook locality lenticular masses of garnet simulate the shapes of fossils. Near the headwaters of Newton Brook recognizable corals occur in a matrix consisting largely of diopside. In general, however, the best-preserved fossils occur in the rocks that are poorest in calc-silicates.

The grade of regional metamorphism is best shown by the aluminous schists of the Littleton Formation. West of Croydon outlier these are typically quartz-muscovite-biotite-almandite-staurolite schists with minor quartz-muscovite-biotite-staurolite-kyanite schists. Sillimanite occurs locally. East of the outlier the dominant types are quartz-muscovite-biotite-almandite-sillimanite schists, locally with staurolite; kyanite appears to be absent. A characteristic assemblage in partings in the lower part of the Clough Formation in the more easterly portions of the outlier is quartz-muscovite-almandite-staurolite-sillimanite. The outlier may thus be regarded as lying partly in the lower sillimanite zone and partly in the upper staurolite zone.

PALEOGEOGRAPHIC IMPLICATIONS

The dating of the Clough Formation at Croydon Mountain makes it possible to estimate the eastward extent of the landmass (Fig. 2) that lay between the Connecticut Valley region and central Pennsylvania and New York during part of Early Silurian (C_3–C_6) time. In New York the eastern transition from marine to nonmarine strata of C_3–C_6 (Clinton) age occurs near Utica (Chadwick, 1918, p. 327); south-southwestward in Pennsylvania it occurs near the Delaware Water Gap (Swartz and Swartz, 1931, Fig. 2). Silurian strata (Boucot and others, 1958, p. 855) occur near Bernardston, Massachusetts, at what appears lithologi-

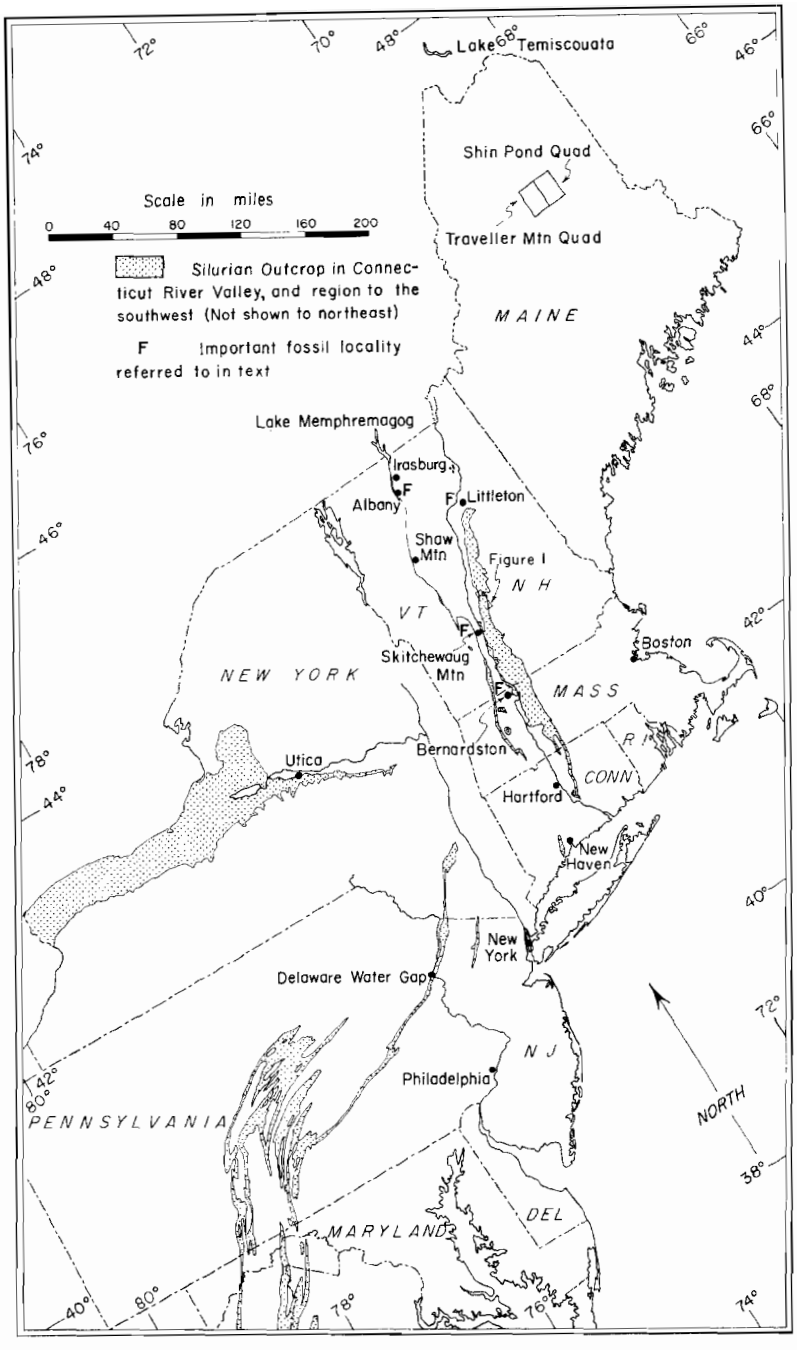

Figure 2. Silurian of the Connecticut Valley region and its relationships to the Silurian exposures of the Central Appalachians. Silurian exposures of Central Appalachians, taken from U. S. Geological Survey map of the United States, include strata of pre- and post-late Llandovery age as well as late Llandovery. Silurian formations of Connecticut Valley include Shaw Mountain, Ayers Cliff, and Northfield Formations in Vermont (Doll and others, 1961); Clough and Fitch Formations of New Hampshire (Billings, 1956 map) and central Massachusetts (Hadley, 1949 map; Peter Robinson, personal communication); Bernardston Formation (in part) of Massachusetts; and Bolton Group (in part) of central Connecticut (Rosenfeld, 1956, p. 1823; 1959). Silurian exposures in western Massachusetts include southern extensions of Northfield Formation (Goshen Schist) shown by Emerson (1917 map). Exposures west of New Haven, Connecticut, show Silurian-Devonian part of Orange Phyllite (Fritts, 1963, p 270–279). Structure in Connecticut Valley region south of Littleton, New Hampshire, is too intricate to permit showing detailed outcrop pattern at this scale.

cally to be the same stratigraphic position as the Croydon occurrence. A stratigraphic sequence similar to that in the Croydon area appears to extend southward through central Massachusetts (Emerson, 1917, Pl. X) and into central Connecticut east of the Connecticut River (Rosenfeld and Eaton, 1956, p. 1823). The present distance from Utica, New York, where marine beds of Clinton age occur to the west and nonmarine beds to the east, to the outcrops of Silurian rocks in the Connecticut Valley is about 140 miles. Allowance for subsequent deformation is difficult (Doll and others, 1961, cross section E-E′), but the landmass must have been quite narrow even if only the position of the Clough Formation is considered as marking the eastern limit. The Shaw Mountain Formation (Currier and Jahns, 1941, p. 1496–1501) of Vermont has, however, also been assigned a Silurian age (Doll, 1951, p. 18–20; Doll and others, 1961). Fossils found near Albany, Vermont, by Konig (1961, p. 32) were referred to Boucot for study and were found to include representatives of the genus *Howellella*. The type of *Howellella* found in the Shaw Mountain has a known stratigraphic range of C_3 (late Llandovery) to early Gedinnian (Manlius-Coeymans). If the Shaw Mountain *Howellella* is of late Llandovery age, and if the age of the Shaw Mountain does not vary much from northeastern Vermont to the southern part of the Connecticut Valley region, the width of the landmass may be reduced still further.

The isopach and lithofacies maps compiled by Amsden (1955, Fig. 2) show a maximum for clastic, largely nonmarine Lower Silurian in eastern Pennsylvania and adjacent northern New Jersey and southeastern New York. This largely nonmarine maximum presents the possibility that the landmass contained an area of great relief which shed the great bulk of its debris to the west rather than to the east (represented by the coarse debris in the Green Pond conglomerate). Amsden's map suggests that the landmass may have been a relatively long, linear feature extending southwest at least as far as northern Georgia, and that another area of relatively high relief existed well to the southeast of northern Georgia (this would account for the marine clastic maximum in that region). The presence of Silurian rocks in the subsurface of northern Florida and adjacent Georgia suggests that the southeastern limit of the possible source area for the maximum in northern Georgia was northwest of the Florida and Georgia subsurface Silurian. However, the Florida subsurface Silurian has not been zoned satisfactorily enough to prove that beds of C_3–C_6 age are present. Kjellesvig-Waering's information (1955, p. 295–297) on eurypterids of Ludlow age is the only published data for the subsurface Silurian in this region, and if C_3–C_6 beds are present, they would have to be sought for in some of the unzoned beds of probable Silurian age beneath the eurypterid beds. The present distance of the Florida subsurface Silurian from the folded beds of northern Alabama and adjacent Georgia is about 200 miles normal to strike. If the transition from marine to nonmarine beds in northern Alabama is similar to that in New York and Pennsylvania, one would assume that it should be present another 50 to 100 miles to the southeast (judged from Amsden's isopachous map, 1955, p. 67). This gives an easterly extent for the southern landmass similar to that for the landmass between the Connecticut River valley and central New York and Pennsylvania. These inferences depend largely upon the exact correlation of the relatively unfossiliferous clastic rocks of the eastern Lower Silurian as shown by Amsden (1955), but the general trends are probably correct.

The northeastern extent of this late Llandovery landmass is difficult to ascertain. Northeast of west-central New Hampshire, marine fossils of C_3–C_6 age are present in the Shin Pond quadrangle of northern Maine, where conglomerates containing *S. lens* cf. *ultima* occur. In the belt extending northeast from northeastern Vermont, marine strata of C_3–C_6 age occur in the region east of Lake Temiscouata, Quebec. The known fossiliferous Silurian rocks in the intervening regions of eastern Quebec and northern Maine are chiefly of early Ludlow age, although a few beds of early Llandovery and C_1 age are now known to the authors. In addition, the unfossiliferous Clough of northern New Hampshire, which underlies the Fitch in places (in some localities the Fitch rests directly upon pre-Silurian rocks), could possibly be of post-Llandovery age. The general similarity of late Llandovery marine faunas does not shed much light on the question of island vs. peninsula: marine larvae, given the proper distribution of temperature and ocean currents, could certainly have been transported freely around such barriers if they did exist.

DESCRIPTIVE PALEONTOLOGY

Genus **Dolerorthis** Schuchert and Cooper, 1931
"*Dolerorthis*" cf. "*D.*" *flabellites* (Foerste, 1890)
(Pl. 1, figs. 1–3)

"*Dolerorthis*" has been recognized only in the Beaver Brook fauna. The pedicle valves show the relatively convex shell form and have strong, unbranched radial costellae. The interior of the pedicle valve has the cordate muscle field, well-developed dental lamellae, and strongly impressed peripheral crenulations that characterize the species. This shell is assigned to "*D.*" cf. "*D.*" *flabellites* because it occurs in an undoubted Silurian fauna. Had the Beaver Brook locality been of Ordovician age, there are a number of Ordovician species to which this form might have been assigned. No brachial valves of this species were recognized in the Beaver Brook fauna, and the pedicle valves are relatively rare.

Genus **Resserella** Bancroft, 1928
Resserella sp.
(Pl. 1, figs. 4–18))

The Beaver Brook and Hetty Brook localities have yielded a number of specimens, chiefly pedicle valves, with the deeply inflated, naviculate form of *Resserella elegantula*. Unfortunately the fine radial ornamentation is not preserved. The occurrence of shells with this form in an undoubted Silurian fauna leaves little doubt that they belong to *Resserella*, although considered by themselves with no external evidence these specimens would not be generically identifiable. The brachial valves are assigned to the genus with a large degree of uncertainty, as the more delicate cardinalia have not been so well preserved as the internal structure of the pedicle valve. The relatively flat brachial valves with their straight hinge line do, however, make reasonable counterparts in these two faunas to the naviculate pedicle valves which so strongly suggest *Resserella*. The absence of preserved radial ornamentation on the brachial valves removes them from consideration as specimens of *Eocoelia hemisphaerica* or *Mesodouvillina*.

Genus **Rhipidomelloides** Boucot and Amsden, 1959
Rhipidomelloides? sp.
(Pl. 2, figs. 1–3)

A few dalmanellid brachial valves from Beaver Brook possess cardinalia suggestive of *Rhipidomelloides*. The presence of stout brachiophores on either side of the cardinal process and the convex brachial valve with a well-impressed adductor field medially divided by a broad myophragm both point toward *Rhipidomelloides*. However, owing to the rarity of the specimens, their relatively incomplete condition (only the posterior portions of three specimens were found), and the absence of recognizable pedicle valves, a positive generic identification cannot be made.

Unidentified rhynchonellid
(Pl. 2, figs. 4–8)

A few specimens from Beaver Brook have the characteristic outline, radial ornamentation, and, in the brachial valve, the well-defined median septum indicative of a rhynchonellid. The material is too rare and too poorly preserved to be generically identifiable.

Genus **Conchidium** Linnaeus, 1760
Conchidium sp.
(Pl. 2, figs. 9–10)

The type locality of the Fitch Formation at the Fitch farm near Littleton, New Hampshire, has yielded a number of specimens of a ribbed pentameroid possessing the characters of *Conchidium*. The specimens are preserved in a somewhat deformed marble containing a certain amount of secondary micaceous material, much of which is found on the surface of some of the fossils. Consequently the preservation of the fossils is poor. No brachial valves have been found. The pedicle valves possess a relatively long median septum and large spondylium as judged from available cross sections (not illustrated), which indicates that they are pentamerinids rather than gypidulinids. Several of the specimens possess highly incurved pedicle-valve beaks of the type present in *Conchidium* but absent in the closely related genus *Rhipidium*.

The identification of *Conchidium* at the Fitch Farm is critical, as it is the only element in the fauna of the Fitch Formation that indicates a zonal position in the lower Ludlow. Without *Conchidium*, the Fitch could have a range of late Llandovery (C_3 or younger) through the Ludlow. *Conchidium* has been recognized in the Sargent Bay limestone of the Memphremagog syncline to the northwest in Quebec (Boucot and Drapeau, in preparation), in unnamed calcareous siltstones of Ludlow age in the Shin Pond quadrangle of northern Maine, and in the Ludlow age beds of the Presque Isle region of Maine, whereas *Rhipidium* has been recognized only in the Chesuncook Lake region of Maine (Berry and Boucot, in preparation). A number of additional localities for *Conchidium* are known in the Eastern townships of Quebec in the area of Lake Temiscouata, and to the northeast in Gaspé.

Cleaves (*in* Billings and Cleaves, 1934, p. 424–425) assigned the Fitch Farm specimens of *Conchidium* to *C. nettelrothi* Hall and Clarke. *C. nettelrothi* has relatively large, undivided radial plications with angular cross sections, very similar to *C. knighti*. The specimens from the Fitch Farm have undivided radial plications, but the plication cross sections are not angular and tend to be relatively small in comparison with such other species of the genus as *C. knighti*. Thus it is unlikely that the Fitch Farm specimens belong to either *C. nettelrothi* or *C. knighti*, although in view of the degree of deformation and the presence of secondary micaceous minerals on the surface of some specimens, it

is possible that originally angular cross sections have been secondarily rounded. At present specific identification of the Fitch Farm specimens seems impractical. It should be noted in passing that *C. nettelrothi* is of Silurian age as suggested by Hall and Clarke (1895, p. 234), despite Nettleroth's statement (1889, p. 58, Pl. 28, 29) that the type specimens originated from the limestones of Middle Devonian age at the Falls of the Ohio, as true *Conchidium* is unknown anywhere in the world above strata of Ludlow age.

Genus **Stricklandia** Billings, 1859
Stricklandia lens cf. *S. lens ultima* Williams, 1951
(Pl. 2, figs. 11–16; Pl. 3, figs. 1–8)

At Hetty Brook and a number of other localities in the Croydon Township area are found abundant specimens of *Stricklandia lens* cf. *S. lens ultima*. The relatively large spondylium and median septum in the pedicle valve, contrasted with the small structures characterizing *Microcardinalia triplesiana* and associated forms, and the relatively large cardinalia in the brachial valve make the specific identification clear. The relatively short brachial plates in the brachial valve could indicate either *Costistricklandia lirata* or the subspecies *S. lens ultima*, but the absence of any trace of the relatively coarse radial costation present in *C. lirata* strongly suggests *S. lens ultima* rather than *C. lirata*. Considering the high degree of metamorphism to which the specimens have been subjected and the seemingly paradoxical association of *S. lens ultima*, known elsewhere from beds of C_4–C_5 age, and *Paleocyclus porpita*, known elsewhere from beds of C_6 and Wenlock age together with strongly costate species of *Stricklandia*, the subspecific identification is made with reservations. The zonal position of the Clough depends in the final analysis almost entirely upon the identification of the *Stricklandia;* otherwise the closest correlation would be late Llandovery (C_3 or younger) to Ludlow age.

Genus **Atrypa** Dalman, 1828
Atrypa "reticularis" (Linnaeus, 1767)
(Pl. 3, figs. 9–16; Pl. 4, figs. 1–13)

Both faunas include atrypoid shells having radial costellae that bifurcate anteriorly and are crossed by strong concentric growth lines, large flabellate muscle fields in the pedicle valve associated with stout hinge teeth unsupported by dental lamellae, and a brachial valve having discrete hinge plates and a broad myophragm bisecting the posteriorly strongly impressed, longitudinally grooved adductor field. The presence of *A. "reticularis"* is important, as it supports the C_3 or younger age determination of the beds, although it is not useful in establishing a precise upper age limit.

Genus **Coelospira** Hall, 1863
Coelospira cf. *C. saffordi* (Foerste, 1903)
(Pl. 4, figs. 14–15)

A single specimen of *C.* cf. *C. saffordi* was found in the Hetty Brook collection. The presence of discrete hinge plates combined with a relatively flat, slightly sulcate brachial valve bearing a pair of median, branched plications shows that it is closely related, if not identical, to *C. saffordi*. *Coelospira* of the *C. saffordi* type is abundant in the Silurian but has not thus far been recognized in the Devonian.

Genus **Eocoelia** Nikiforova, 1961
Eocoelia cf. *E. hemisphaerica* (Sowerby, 1839)
(Pl. 4, figs. 16–21; Pl. 5, figs. 1–15)

The Beaver Brook fauna contains a leptocoelid possessing a cardinal plate in the adult derived from the discrete hinge plates in small individuals. The brachial valve is relatively flat and the pedicle valve convex. Both valves are ornamented by simple plications that increase in size anteriorly, but do not bifurcate. The muscle field of the brachial valve is medially bisected by a broad, low myophragm. Hinge teeth unsupported by dental lamellae are present in the pedicle valve. *E. hemisphaerica* has a known stratigraphic range of C_3–C_5. The nearest occurrence to the northeast of similar shells is near Blanshard Pond, Kennebago Lake quadrangle, Franklin County, Maine.

Genus **Cyrtia** Dalman, 1828
Cyrtia? sp.
(Pl. 5, fig. 16)

A single specimen from Hetty Brook, interpreted as a pedicle valve, appears to represent the posterior impression of *Cyrtia*. Two long slits are inferred to have been the positions of the dental lamellae. Possibly this is a peculiarly sheared and distorted pedicle valve of *Eospirifer*.

Genus **Eospirifer** Schuchert, 1913
Eospirifer cf. *E. radiatus* (Sowerby, 1825)
(Pl. 6, figs. 10–16)

Hetty Brook has yielded a number of spiriferoid pedicle valves possessing a sulcus, relatively long dental lamellae, an unplicated exterior, and an incurved beak that can only be interpreted as *Eospirifer*. The absence of any brachial valves, or the preservation of any of the fine ornamentation, is vexing, but the large size of the specimens as well as their other characteristics precludes assignment to the only other reasonable Silurian possibility, *Howellella*.

Genus **Howellella** Kozlowski, 1946
Howellella sp. 1
(Pl. 6, figs. 17–19)

The Fitch Formation at the Fitch Farm has yielded a few specimens of a small costate spiriferoid with a laterally elongate outline and without a median septum in the pedicle valve. These characters indicate *Howellella*, but the specific identity of the material cannot be determined. This is the material that Billings and Cleaves (1934, p. 425) assigned to "*Spirifer* sp. ind." Spiriferids of this type are unknown below strata of C_3 age.

Howellella sp. 2
(Pl. 6, figs. 20–21)

The Hetty Brook locality has yielded a single pedicle valve of *Howellella* characterized by a relatively subcircular outline, short dental lamellae, a prominent sulcus, and unplicated flanks. This shell is quite distinct from the *Howellella* found in the Fitch or the Shaw Mountain Formations.

Genus **Meristina** Hall, 1867
Meristina ? sp.
(Pl. 6, figs. 1–2)

A single pedicle valve from Beaver Brook possesses a subtrapezoidal muscle field, obsolescent dental lamellae, and smooth exterior, all of which suggest affinities with the meristellids. As the Beaver Brook beds are, on other evidence, of undoubted Silurian age, this specimen probably belongs to *Meristina* rather than to the very similar genus *Meristella*, which is unknown below strata of Devonian age.

Rostrospiroid?
(Pl. 5, figs. 17–21)

A small number of smooth brachial valves from Hetty Brook are internally characterized by a prominent median septum. These shells are probably rostrospiroids, but no generic affinities can be suggested.

Genus **Plectodonta** Kozlowski, 1929
Plectodonta sp.
(Pl. 6, figs. 3–9; Pl. 7, figs. 1–6)

Both pedicle and brachial valves of *Plectodonta* have been found at the Hetty Brook locality. The brachial valves are gently concave, show no traces of relatively fine radial ornamentation due to destruction by metamorphism, and have a straight hinge line. The interior impressions of the brachial valves reveal little about the cardinalia, but two pairs of lateral septae are visible on most specimens. The pedicle valves are highly convex and have a straight hinge line. The internal structures of the pedicle valves are relatively subdued, but the posteriorly projecting impressions of the muscle field can be discerned in a few specimens. The crenulations ordinarily present along the hinge line have not been preserved.

Genus **Leptaena** Dalman, 1828
Leptaena cf. *L.* "*rhomboidalis*" (Wilckens, 1769)
(Pl. 7, figs. 7–11)

A few fragmentary specimens of *L.* "*rhomboidalis*" are present in the Hetty Brook fauna. Externally these specimens display the reticulate ornamenta- and the geniculate form of the species. Internally the specimens display the characteristic form of the muscle field in the pedicle valve and that of the cardinalia in the brachial valve.

Genus **Mesodouvillina** Williams, 1950
Mesodouvillina sp.
(Pl. 8, figs. 12–20)

The Beaver Brook fauna includes a number of pedicle valves that have the external form of strophеodontids, including a straight hinge line, gently convex cross section, and radial ornamentation of fine and very fine radial costellae. In the interior, stout muscle-bounding ridges are present, and anterior to these low ridges extend anterolaterally.

Genus **Leptostrophia** Hall and Clarke, 1892
Leptostrophia? sp.
(Pl. 7, figs. 15–17; Pl. 8, figs. 1–11)

The Beaver Brook fauna contains a number of smooth shells of strophеodontid type. The pedicle valves are gently convex, and the brachial valves relatively flat. The interior of the pedicle valve is characterized by stout muscle-bounding ridges and a posteriorly projecting muscle field. The brachial valve is characterized by divided cardinal process lobes. These specimens may belong to *Leptostrophia*.

Genus **Amphistrophia** Hall and Clarke, 1892
Amphistorphia cf. *A. funiculata* (McCoy, 1846)
(Pl. 9, figs. 1–2)

Amphistrophia funiculata was listed from the Fitch Formation by Billings and Cleaves (1934, p. 424), but illustrations adequate to confirm the identification were absent. The available specimens show a medium-sized shell, anteriorly geniculate, with strong radial ornamentation of fine and coarse costellae. Specimens showing the internal features of the shell are not available in the collections.

Unidentified strophomenoids
(Pl. 7, figs. 12–14)

Beaver Brook has yielded several strophomenoids that could not be further identified. One pedicle valve (Pl. 7, fig. 12) suggests that the internal structures of *Leptostrophia* might be present. One brachial valve (Pl. 7, figs. 13–14) is very puzzling.

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EXPLANATION OF PLATES 1–10

Specimens deposited in the collection of the U. S. National Museum, Washington, D.C., are designated by USNM; those in the Museum of Comparative Zoology, Cambridge, Massachusetts, by MCZ.

PLATE 1. SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

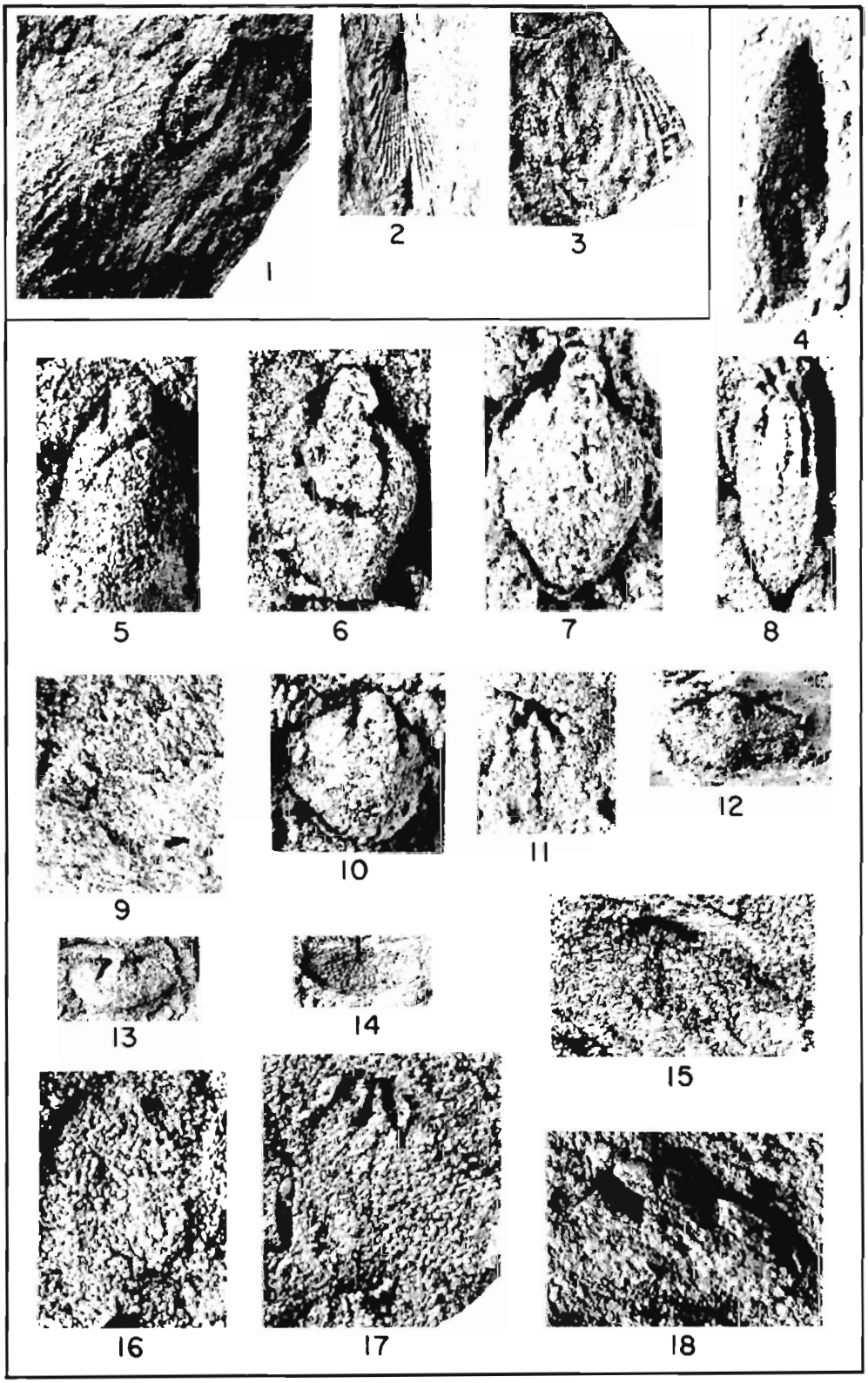
Figures

1–3. *"Dolerorthis"* cf. *"D." flabellites* (Foerste, 1890). Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

1. Impression of pedicle interior (× 2) showing impression of dental lamellae, cordate muscle field, and anteriorly pronounced peripheral crenulations; USNM No. 139922
2. Impression of pedicle exterior (× 1) showing strong, unbranched radial costellae; USNM No. 139923
3. Impression of pedicle exterior (× 1) showing strong, unbranched radial costellae; USNM No. 139926a

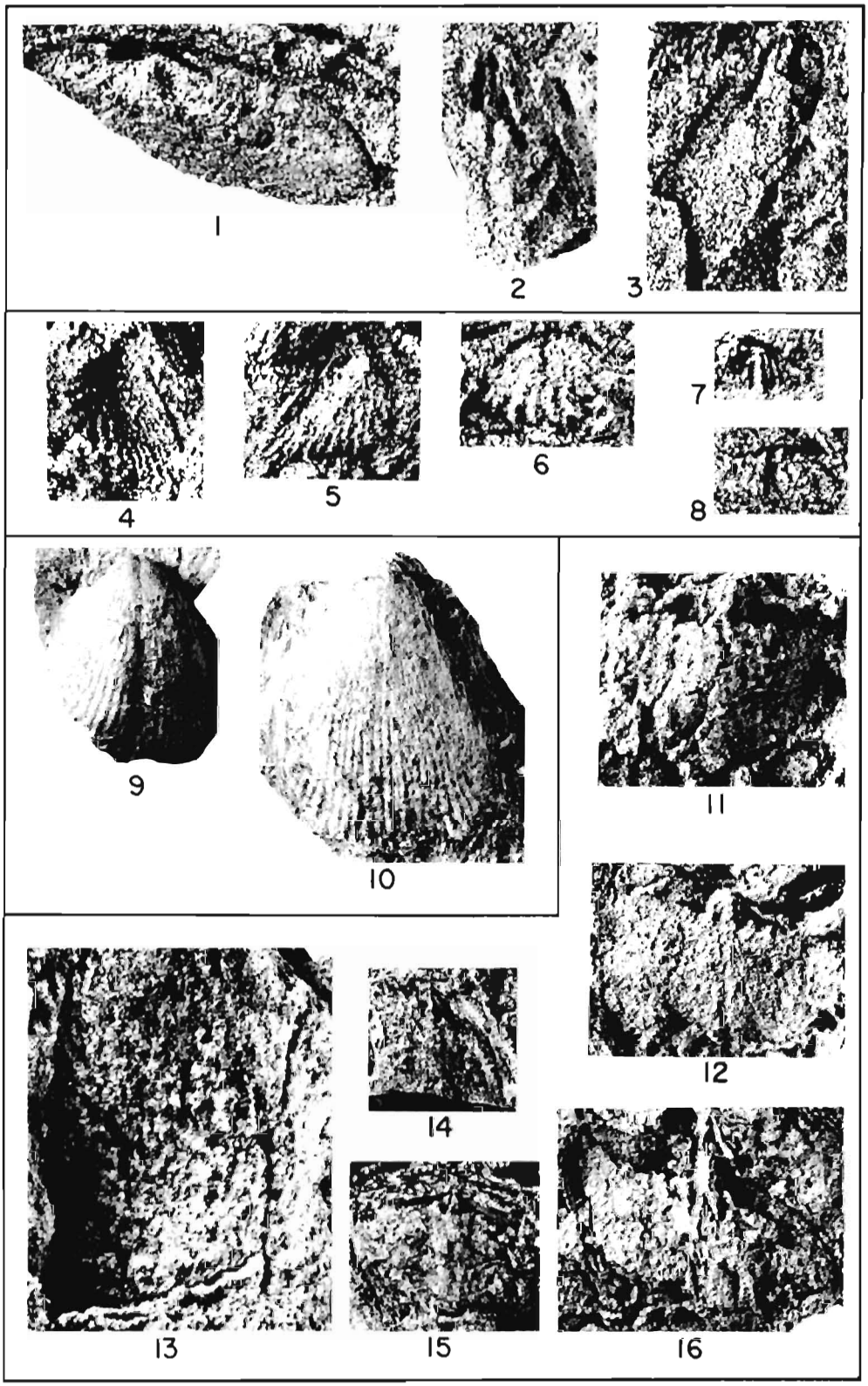
4–18. *Resserella* sp. Upper part of Clough Formation; Beaver and Hetty brooks, Croydon Township, near Claremont

4. Impression of pedicle exterior (× 3) showing relatively deep, naviculate form of shell despite high degree of lateral compression to which it has been subjected (counterpart of Fig. 8); Beaver Brook; USNM No. 139943
5. Impression of pedicle interior (× 3) showing short dental lamellae, elongate outline, and naviculate form of shell; Beaver Brook; USNM No. 139941
6. Impression of pedicle interior (× 3) showing short dental lamellae, cordate muscle field extending posterior of hinge line, and naviculate form (posterior half of specimen has been recemented to anterior half); Hetty Brook; USNM No. 139947
7. Impression of pedicle interior (× 3) showing short dental lamellae, posterior extent of cordate muscle field, elongate outline, and relatively naviculate outline; Hetty Brook; USNM No. 139944
8. Impression of pedicle interior (× 3) showing short dental lamellae, cordate muscle field, and elongate outline despite great lateral compression of specimen (counterpart of Fig. 4); Beaver Brook; USNM No. 139942
9. Impression of brachial exterior (× 3) showing absence of radial ornamentation (counterpart of Fig. 11); Hetty Brook; USNM No. 139946
10. Impression of pedicle interior (× 3) showing short dental lamellae, posterior extent of cordate muscle field, and subcircular outline; Hetty Brook; USNM No. 139948
11. Impression of brachial interior (× 3) showing straight hinge line, stout brachiophore impressions, and prominent myophragm (counterpart of Fig. 9). Dental-socket crenulations cannot be proved present. Generic identity of this specimen still questionable. Hetty Brook; USNM No. 139945
12. Impression of pedicle interior (× 2) showing short dental lamellae; Hetty Brook; USNM No. 139955
13. Impression of pedicle interior (× 1) showing short dental lamellae and cordate muscle field despite high degree of lateral elongation specimen has undergone (counterpart of Fig. 14); Beaver Brook; USNM No. 139949
14. Impression of pedicle exterior (× 1) showing absence of radial ornamentation (counterpart of Fig. 13); Beaver Brook; USNM No. 139950
15. Impression of exterior (brachial view) (× 2) showing absence of radial ornamentation (counterpart of Fig. 18); Beaver Brook; USNM No. 139954
16. Impression of brachial exterior (× 2) showing absence of radial ornamentation (counterpart of Fig. 17); Beaver Brook; USNM No. 139951
17. Impression of brachial interior (× 2) showing stout brachiophores (counterpart of Fig. 16). Generic identity of this specimen is in considerable doubt. Absence of radial ornamentation on counterpart removes it from consideration as either *E. hemisphaerica* or *Mesodouvillina; Resserella* is a strong possibility as radial ornamentation has not been preserved in any of the specimens of *Resserella*. Beaver Brook; USNM No. 139952
18. Impression of interior (brachial view) (× 2) showing impression of stout brachiophores and short dental lamellae, and posterior projection of muscle field impression of pedicle valve behind hinge line (counterpart of Fig. 15). Specimen lacks preserved radial ornamentation on impression of exterior; this combined with its internal form suggests *Resserella*. Beaver Brook; USNM No. 139953



SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 1
Geological Society of America Bulletin, volume 74



SILURIAN BRACHIOPODS, CLOUGH AND FITCH FORMATIONS, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 2
Geological Society of America Bulletin, volume 74

PLATE 2. SILURIAN BRACHIOPODS, CLOUGH AND FITCH FORMATIONS, NEW HAMPSHIRE

Figures

1–3. *Rhipidomelloides*? sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

1. Impression of brachial interior (× 3) showing stout brachiophores and convex valve form despite high degree of lateral distortion. Adductor impressions are separated by broad, low myophragm. A cardinal-process impression is probably present immediately posterior to tip of muscle field. USNM No. 139956
2. Impression of brachial interior (× 3) showing stout brachiophores, impression of cardinal process, and low myophragm dividing adductor field; USNM No. 139958
3. Impression of brachial interior (× 2) showing stout brachiophores and impression of a cardinal process. Muscle-field impression not preserved. Shell dalmanellid in form of its cardinalia, and *Rhipidomelloides* seems a reasonable possibility. USNM No. 139957

4–8. Unidentified rhynchonellid. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

4. Impression of pedicle exterior (× 3) showing radial costellae and rhynchonelliform outline (counterpart of Fig. 5); USNM No. 139959
5. Impression of pedicle interior (× 3) showing peripheral impression of external ornamentation, rhynchonelliform outline (counterpart of Fig. 4); USNM No. 139960
6. Impression of brachial interior (× 3) showing median septum, radial ornamentation, rhynchonelliform outline; USNM No. 139963
7. Impression of brachial exterior (× 3) showing radial ornamentation (counterpart of Fig. 8) Affinities of this specimen difficult to ascertain, but presence of median septum and radial costellae suggests affinities with the rhynchonellids, particularly when other elements in the fauna are considered. USNM No. 139962
8. Impression of brachial interior (× 3) showing prominent median septum (counterpart of Fig. 7); USNM No. 139961

9–10. *Conchidium* sp. Fitch Formation; Fitch Farm (loc. 3 of Billings and Cleaves, 1934, p. 416), near Littleton

9. Exterior of pedicle valve (× 1) showing weak sulcus; MCZ No. 8655 (Billings and Cleaves, 1934, Pl. II, fig. 9).
10. Exterior of pedicle valve (× 1) showing absence of sulcus; MCZ No. 8656 (Billings and Cleaves, 1934, Pl. II, fig. 8)

11–16. *Stricklandia lens* cf. *S. lens ultima* Williams, 1951. Upper part of Clough Formation; Hetty Brook Croydon Township, near Claremont

11. Impression of brachial interior (× 2) showing relatively short notches occupied by brachial plates; USNM No. 139967
12. Impression of brachial interior (× 2) showing relatively short notches occupied by brachial plates; USNM No. 139966a
13. Impression of brachial exterior (× 3) showing absence of prominent radial ornamentation (counterpart of Pl. 3, fig. 1); USNM No. 139969a
14. Impression of brachial interior (× 1) showing relatively short notches occupied by brachial plates; USNM No. 139964
15. Impression of brachial interior (× 1) showing relatively short notches occupied by brachial plates, relatively large size of cardinalia; USNM No. 139965
16. Impression of brachial interior (× 2) showing slightly longer notches occupied by brachial plates (extra length probably due to shell having been more deformed fore and aft than other figured brachial valves); USNM No. 139968

PLATE 3. SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

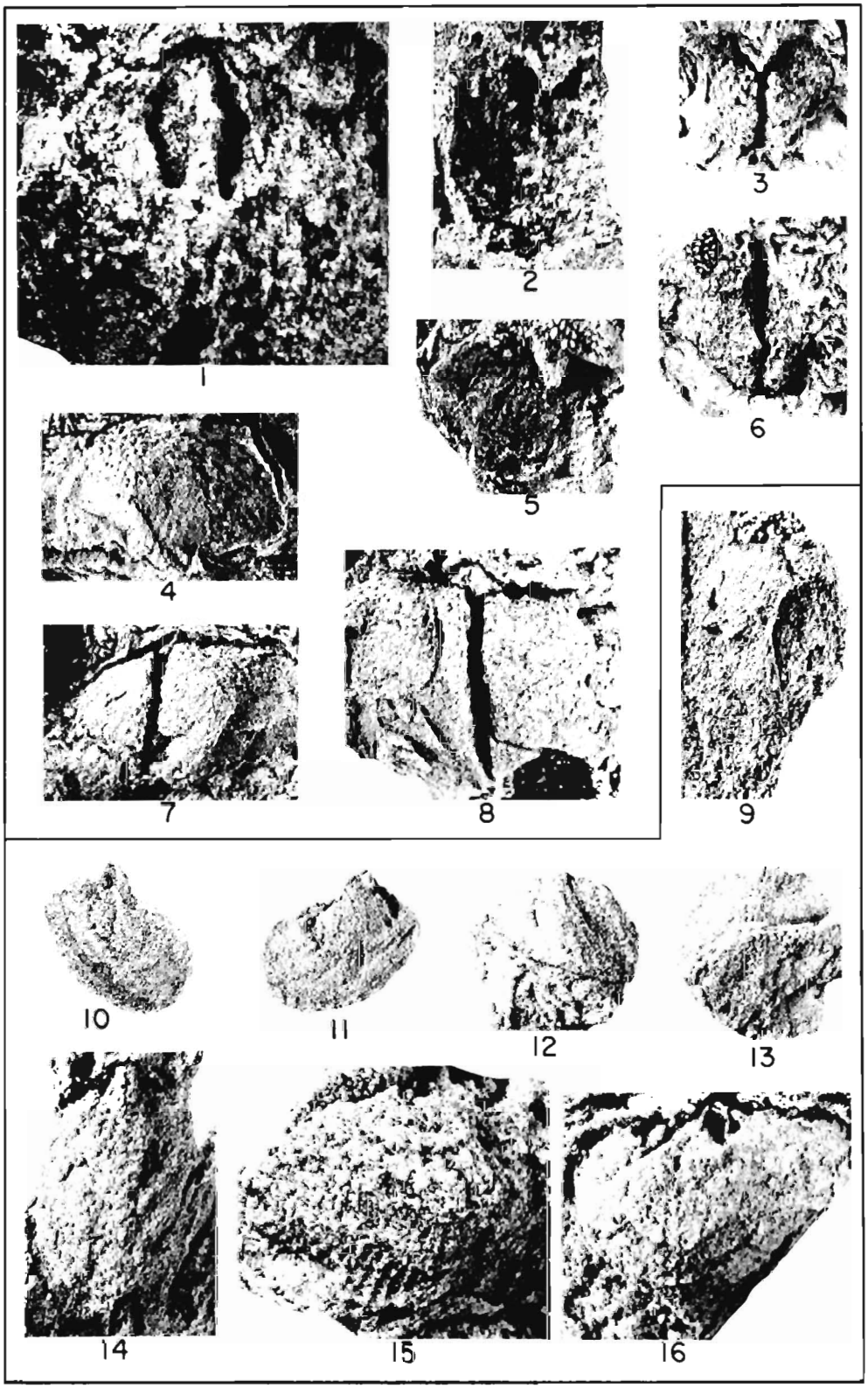
Figures

1–8. *Stricklandia lens* cf. *S. lens ultima* Williams, 1951. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

1. Impression of brachial interior (× 3) showing relatively short notches occupied by brachial plates (counterpart of Pl. 2, fig. 13); USNM No. 139970a
2. Impression of pedicle exterior (× 2) showing absence of radial ornamentation (counterpart of Fig. 6); USNM No. 139974
3. Impression of pedicle interior (× 1) showing relatively large spondylium, prominent median septum; USNM No. 139972
4. Impression of pedicle exterior (× 1) showing absence of radial ornamentation (counterpart of Fig. 7); USNM No. 139976
5. Impression of pedicle exterior and spondylium filling (× 1) showing absence of radial ornamentation on exterior, relatively large size of spondylium, and relatively short interarea; USNM No. 139971a
6. Impression of pedicle interior (× 1) showing relatively large spondylium, median septum (counterpart of Fig. 2); USNM No. 139973
7. Impression of pedicle interior (× 1); shearing has shifted median septum to left, obscuring spondylium filling (counterpart of Fig. 4); USNM No. 139975
8. Impression of pedicle interior (× 2) showing prominent median septum, spondylium filling; USNM No. 139977

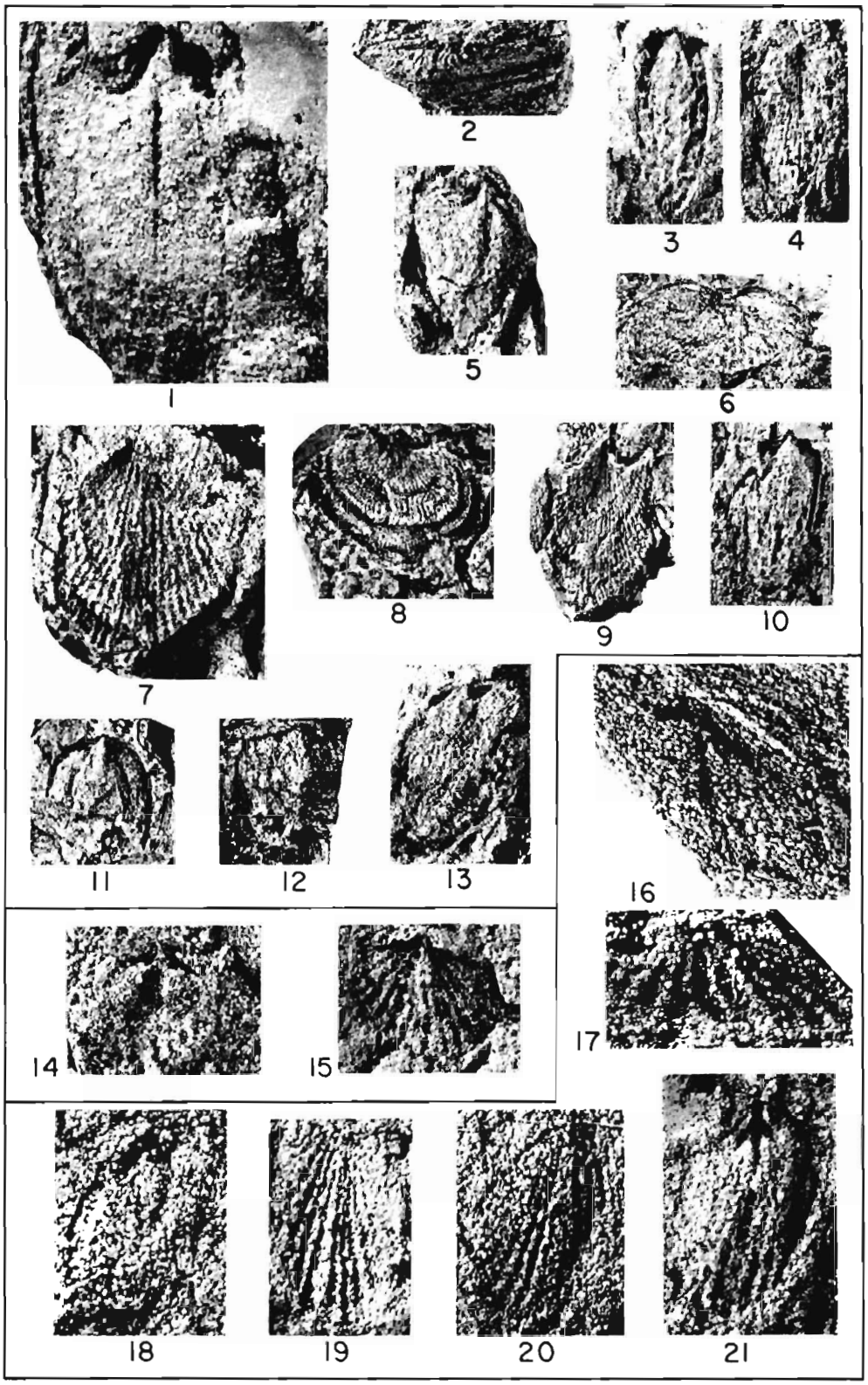
9–16. *Atrypa* "*reticularis*" (Linnaeus, 1767). Upper part of Clough Formation; Beaver and Hetty brooks, Croydon Township, near Claremont

9. Impression of brachial interior (× 2) showing broad myophragm posteriorly bisecting muscle field just anterior to diductor attachment area. Longitudinal slits originally present on diductor attachment area not preserved, but hinge plates lateral to it are well preserved. Beaver Brook; USNM No. 139981
10. Impression of interior (brachial view) (× 1) showing myophragm bisecting muscle field; Beaver Brook; USNM No. 139980
11. Impression of interior (pedicle view) (× 1) showing flabellate muscle field; Beaver Brook; USNM No. 139980
12. Impression of pedicle interior (× 1) showing sheared flabellate muscle impression (counterpart of this specimen possesses *Atrypa*-type radial ornamentation); Beaver Brook; USNM No. 139978
13. Impression of brachial interior (× 1) showing myophragm dividing posterior portion of muscle field; Beaver Brook; USNM No. 139978
14. Impression of pedicle interior (× 2) showing well-defined hinge teeth impressions with subcircular cross section; Hetty Brook; USNM No. 139985
15. Impression of brachial interior (× 3) showing peripheral crenulations, posteriorly well-defined muscle field; Hetty Brook; USNM No. 139987
16. Impression of brachial interior (× 2) showing posteriorly well-defined muscle field medially separated by broad, low myophragm, convexity of valve, lack of dental socket crenulations; Hetty Brook; USNM No. 139986a



SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 3
Geological Society of America Bulletin, volume 74



SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 4
Geological Society of America Bulletin, volume 74

PLATE 4. SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

Figures

1–13. *Atrypa "reticularis"* (Linnaeus, 1767). Upper part of Clough Formation; Beaver and Hetty brooks, Croydon Township, near Claremont

1. Impression of brachial interior (× 3) showing prominent myophragm dividing muscle field, well-defined hinge plates (the slitlike striations of diductor attachment area and crenulations of dental sockets have not been preserved); Hetty Brook; USNM No. 139984
2. Impression of brachial interior (× 1) showing paired, longitudinally grooved impressions of adductors medially bisected by low myophragm; Beaver Brook; USNM No. 139982
3. Impression of pedicle interior (× 1) showing flabellate muscle field and stout hinge teeth, despite great degree of secondary elongation to which specimen has been subjected; Beaver Brook; USNM No. 139988
4. Impression of pedicle exterior (× 1) showing relative flatness of valve; Beaver Brook; USNM No. 139989
5. Impression of brachial interior (× 3) showing myophragm bisecting muscle field, divided hinge plates (crenulations on floor of dental sockets have not been preserved); Hetty Brook; USNM No. 139983
6. Impression of pedicle exterior (× 1) showing radial costellae; Beaver Brook; USNM No. 139991a
7. Impression of pedicle exterior (× 2) showing relatively flat valve, anteriorly bifurcating costellae; Hetty Brook; USNM No. 139994
8. Impression of pedicle exterior (× 1) showing weak, anteriorly developed sulcus, strong concentric growth lines, radial costellae; Hetty Brook; USNM No. 139996
9. Impression of pedicle exterior (× 1) showing relatively flat valve, radial costellae; Hetty Brook; USNM No. 139997
10. Impression of pedicle interior (× 1) showing relatively flabellate muscle field, stout hinge teeth; Beaver Brook; USNM No. 139992
11. Impression of pedicle interior (× 1) showing flabellate muscle field, stout hinge teeth; Hetty Brook; USNM No. 139995
12. Impression of pedicle interior (× 1) showing stout hinge teeth; Hetty Brook; USNM No. 139993
13. Impression of pedicle interior (× 1) showing stout hinge teeth, absence of dental lamellae; Beaver Brook; USNM No. 139990a

14–15. *Coelospira* cf. *C. saffordi* (Foerste, 1903). Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

14. Impression of brachial interior (× 3) showing discrete hinge plates (counterpart of Fig. 15); USNM No. 139998
15. Impression of brachial exterior (× 3) showing weak sulcus, medially bifurcating costellae (counterpart of Fig. 14); USNM No. 139999

16–21. *Eocoelia* cf. *E. hemisphaerica* (Sowerby, 1839). Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

16. Impression of brachial interior (× 3) showing broad, low posterior myophragm, cardinal plate bearing median trough; USNM No. 140006
17. Impression of brachial exterior (× 3) showing absence of anteriorly bifurcating costellae despite shearing; USNM No. 140000
18. Impression of brachial interior (× 3) showing cardinal plate bearing median trough; USNM No. 140008
19. Impression of brachial exterior (× 3) showing unbranched costellae; USNM No. 140005
20. Impression of brachial exterior (× 3) showing costellae; USNM No. 140003a
21. Impression of brachial interior (× 3) showing pit for cardinal plate formed from conjunct hinge plates; USNM No. 140004a

PLATE 5. SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

Figures

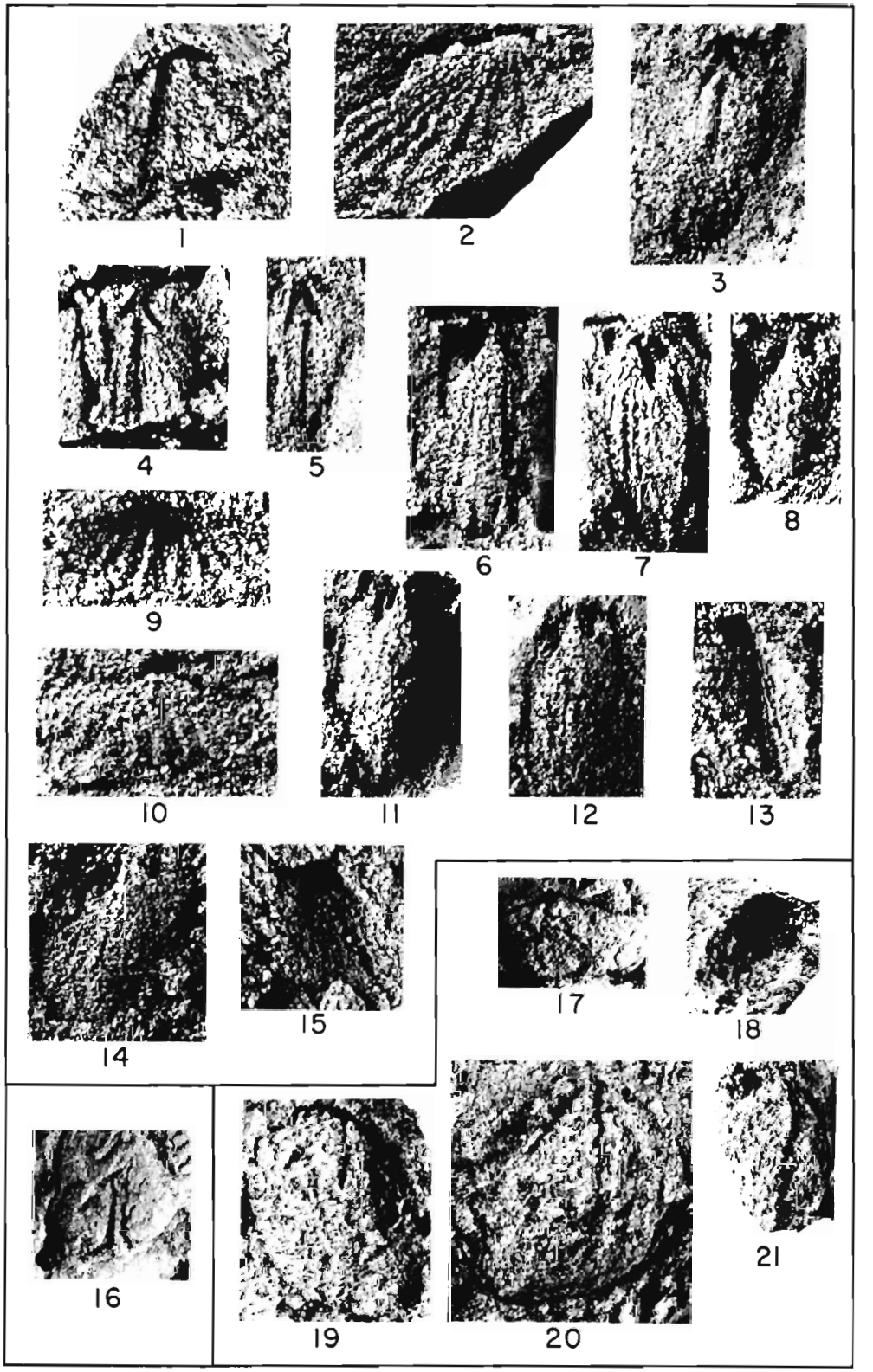
1–15. *Eocoelia* cf. *E. hemisphaerica* (Sowerby, 1839). Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

1. Impression of brachial interior (× 3) showing prominent, low myophragm, discrete hinge plates (counterpart of Pl. 4, fig. 17); USNM No. 140001
2. Impression of brachial exterior (× 3) showing relatively flat valve bearing unbranched plications (counterpart of Pl. 4, fig. 16); USNM No. 140007
3. Impression of brachial interior (× 3) showing myophragm, cardinal plate; USNM No. 140009
4. Impression of brachial interior (× 3) showing prominent myophragm, discrete hinge plates; USNM No. 140002a
5. Impression of brachial interior (× 3) showing myophragm, cardinal plate (valve has been secondarily elongated to a high degree); USNM No. 140010
6. Impression of pedicle interior (× 3) showing impress of radial plicae, stout hinge teeth; USNM No. 140017a
7. Impression of pedicle interior (× 3) showing impress of radial plicae, stout hinge teeth; USNM No. 140020
8. Impression of pedicle interior (× 3) showing stout hinge teeth (counterpart of Fig. 13); USNM No. 140016
9. Impression of pedicle exterior (× 3) showing unbranched plications; USNM No. 140011
10. Impression of pedicle interior (× 3) showing impress of plications (counterpart of Fig. 9); USNM No. 140012
11. Impression of pedicle interior (× 3) showing stout hinge teeth and grooves lateral to them; USNM No. 140018a
12. Impression of pedicle interior (× 3) showing stout hinge teeth; USNM No. 140019
13. Impression of pedicle exterior (× 3) showing radial plications (counterpart of Fig. 8); USNM No. 140015
14. Impression of pedicle interior (× 3) showing stout hinge teeth unsupported by dental lamellae (counterpart of Fig. 15); USNM No. 140014
15. Impression of pedicle exterior (× 3) showing subcircular outline, degree of convexity (counterpart of Fig. 14); USNM No. 140013

16. *Cyrtia*? sp. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont. Impression of pedicle interior (× 2) showing subparallel slits, interpreted as impressions of dental lamellae; USNM No. 140021

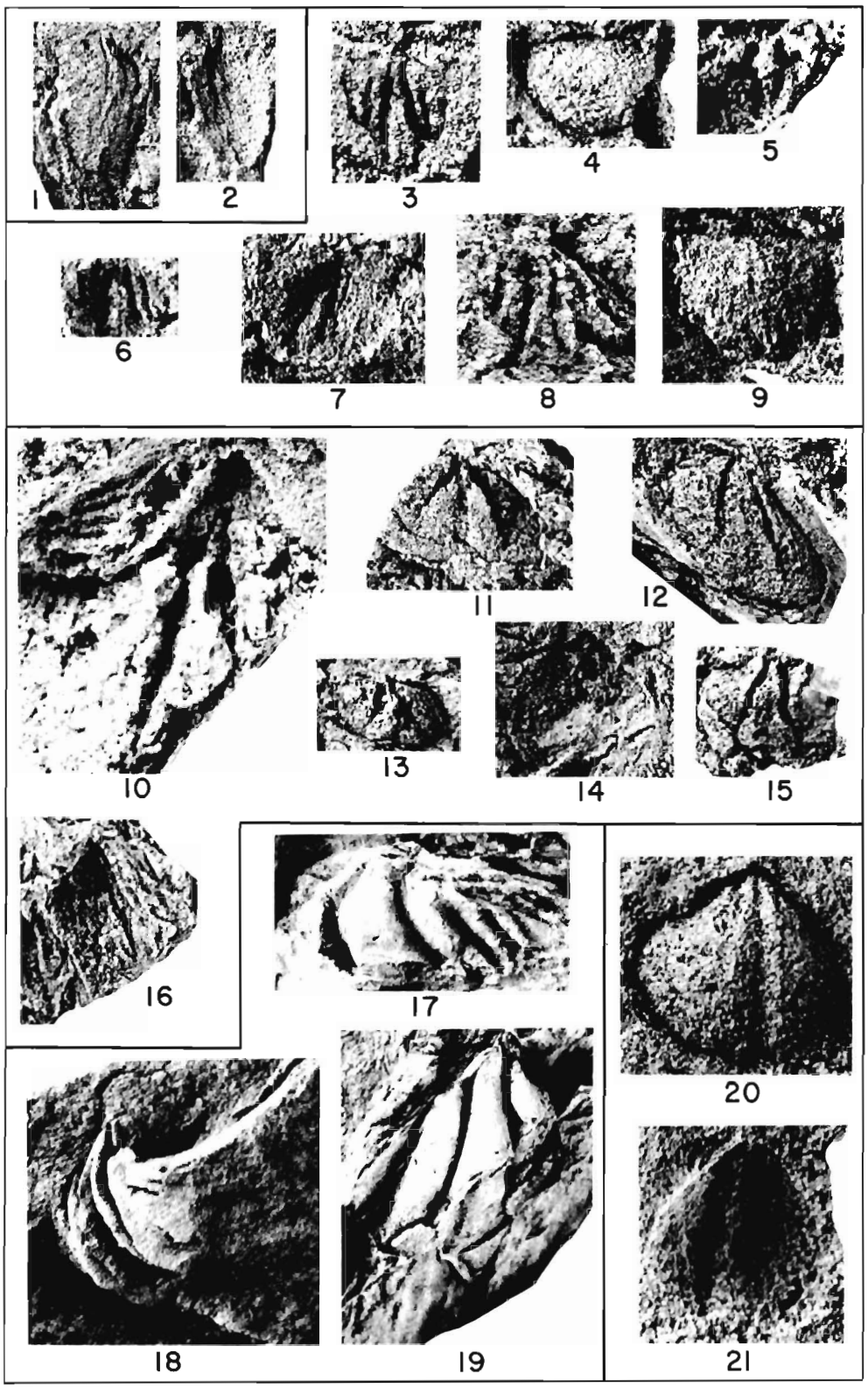
17–21. Rostrospiroid? Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

17. Impression of brachial interior (× 2) showing median septum; USNM No. 140035
18. Impression of brachial exterior (× 3) showing smooth exterior (counterpart of Fig. 21); USNM No. 140034
19. Impression of brachial interior (× 3) showing median septum; USNM No. 140036
20. Impression of brachial interior (× 3) showing impression of median septum, absence of radial ornamentation; USNM No. 140037
21. Impression of brachial interior (× 3) showing median septum (counterpart of Fig. 18); USNM No. 140033



SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 5
Geological Society of America Bulletin, volume 74



SILURIAN BRACHIOPODS, CLOUGH AND FITCH FORMATIONS, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 6
Geological Society of America Bulletin, volume 74

PLATE 6. SILURIAN BRACHIOPODS, CLOUGH AND FITCH FORMATIONS, NEW HAMPSHIRE

Figures

1–2. *Meristina*? sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

1. Impression of pedicle interior (× 1) showing posteriorly obsolescent dental lamellae, subtrapezoidal muscle field (counterpart of Fig. 2); USNM No. 140031
2. Impression of pedicle exterior (× 1) showing smooth exterior (counterpart of Fig. 1); USNM No. 140032

3–9. *Plectodonta* sp. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

3. Impression of brachial interior (× 3) showing two pairs of lateral septae, concave form; USNM No. 140038
4. Impression of brachial exterior (× 3) showing concave form, absence of radial ornamentation; USNM No. 140039a
5. Impression of brachial interior (× 3) showing two pairs of lateral septae; USNM No. 140042
6. Impression of brachial interior (× 3) showing two pairs of lateral septae; USNM No. 140043a
7. Impression of brachial interior (× 3) showing concave form, two pairs of lateral septae (counterpart of Fig. 9); USNM No. 140041
8. Impression of brachial interior (× 3) showing two pairs of lateral septae; USNM No. 140039b
9. Impression of brachial exterior (× 3) showing concave form, straight hinge line, absence of radial ornamentation (counterpart of Fig. 7); USNM No. 140040

10–16. *Eospirifer* cf. *E. radiatus* (Sowerby, 1825). Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

10. Impression of pedicle interior (× 2) showing strong dental lamellae, incurved beak (counterpart of Fig. 16); USNM No. 140023
11. Impression of pedicle interior (× 1) showing form of muscle field, length of dental lamellae; USNM No. 140025
12. Impression of pedicle interior (× 1) showing long dental lamellae and sulcus, laterally elongate outline; USNM No. 140022
13. Impression of pedicle interior (× 1) showing length of dental lamellae; USNM No. 140026
14. Impression of pedicle exterior (× 1) showing absence of coarse or fine radial ornamentation (counterpart of Fig. 15); USNM No. 140028
15. Impression of pedicle interior (× 1) showing length of dental lamellae (counterpart of Fig. 14); USNM No. 140027
16. Impression of pedicle exterior (× 1) showing absence of fine or coarse radial ornamentation (counterpart of Fig. 10); USNM No. 140024

17–19. *Howellella* sp. 1. Fitch Formation; Locality 3 of Billings and Cleaves (1934, p. 416), Fitch Farm, near Littleton

17. Impression of brachial interior (× 3) showing relative breadth of fold and U-shaped interspaces between lateral plications (this specimen referred to in Billings and Cleaves, 1934, p. 425, as "*Spirifer* sp. ind."); MCZ No. 8659
18. Impression of pedicle interior (× 3) showing length of dental lamellae, raised median portion of muscle field; MCZ unnumbered
19. Impression of brachial interior (× 3) showing only the somewhat compressed fold and first lateral ribs of postero-median portion of valve; MCZ unnumbered

20–21. *Howellella* sp. 2. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

20. Impression of pedicle interior (× 3) showing relatively short dental lamellae, sulcus (counterpart of Fig. 21); USNM No. 140030
21. Impression of pedicle exterior (× 3) showing relatively subcircular outline, absence of lateral plications, presence of sulcus (counterpart of Fig. 20); USNM No. 140029

PLATE 7. SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

Figures

1–6. *Plectodonta* sp. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

1. Impression of pedicle interior (× 2) showing straight hinge line, convex laterally elongate form; USNM No. 140044
2. Impression of pedicle interior (× 3) showing convex form, laterally elongate outline; USNM No. 140045
3. Impression of pedicle exterior (× 3) showing highly convex form, absence of radial ornamentation (counterpart of Fig. 4); USNM No. 140046
4. Impression of pedicle interior (× 3) showing posterior form of muscle field (counterpart of Fig. 3); USNM No. 140047
5. Impression of pedicle interior (× 3) showing convex form, outline of valve, straight hinge line; USNM No. 140048
6. Impression of pedicle interior (× 3) showing outline of valve, convexity; USNM No. 140049

7–11. *Leptaena* cf. *L. "rhomboidalis"* (Wilckens, 1769). Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont

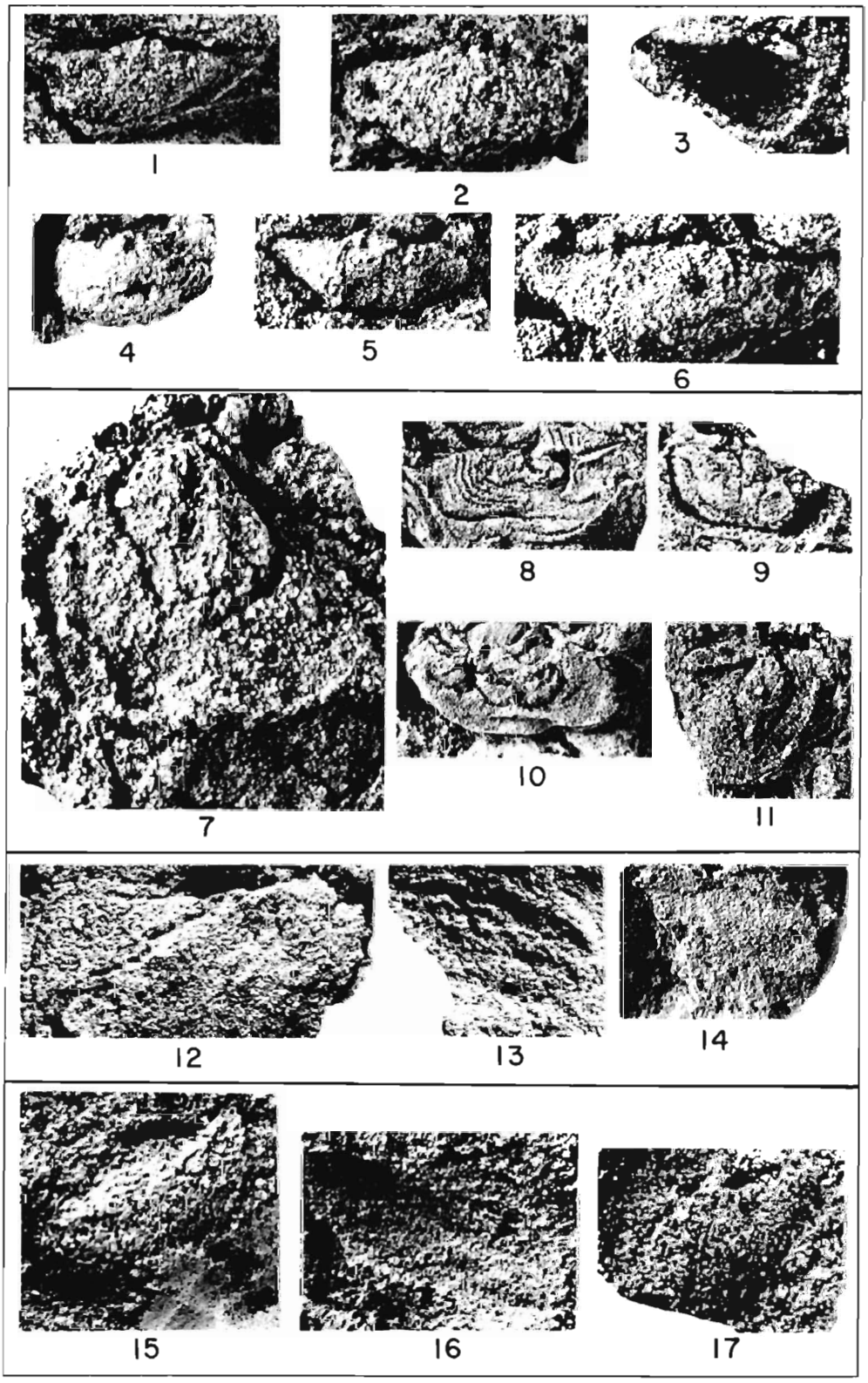
7. Impression of pedicle interior (× 2) showing geniculate anterior margin, impression of muscle field; USNM No. 140051
8. Impression of pedicle exterior (× 1) showing concentric ornamentation and fine, radial ornamentation combining to give typical "reticulate" effect (counterpart of Fig. 10); USNM No. 140052
9. Impression of brachial interior (× 1) showing median myophragm, impression of cardinal-process lobes; USNM. No. 140054
10. Impression of pedicle interior (× 1) showing geniculate anterior margin, anterior form of muscle field (counterpart of Fig. 8); USNM No. 140053
11. Impression of pedicle interior (× 1) showing impressions of dental lamellae, straight hinge line; USNM No. 140050

12–14. Unidentified strophomenoids. Upper part of Clough Formation, Beaver Brook, Croydon Township, near Claremont

12. Impression of pedicle interior (× 2) showing relatively large ridges bounding muscle field; USNM No. 140078
13. Impression of brachial interior (× 2) showing low, posterior myophragm (counterpart of Fig. 14); USNM No. 140079
14. Impression of brachial exterior (× 1) showing relatively flat, smooth form (counterpart of Fig. 13); USNM No. 140080

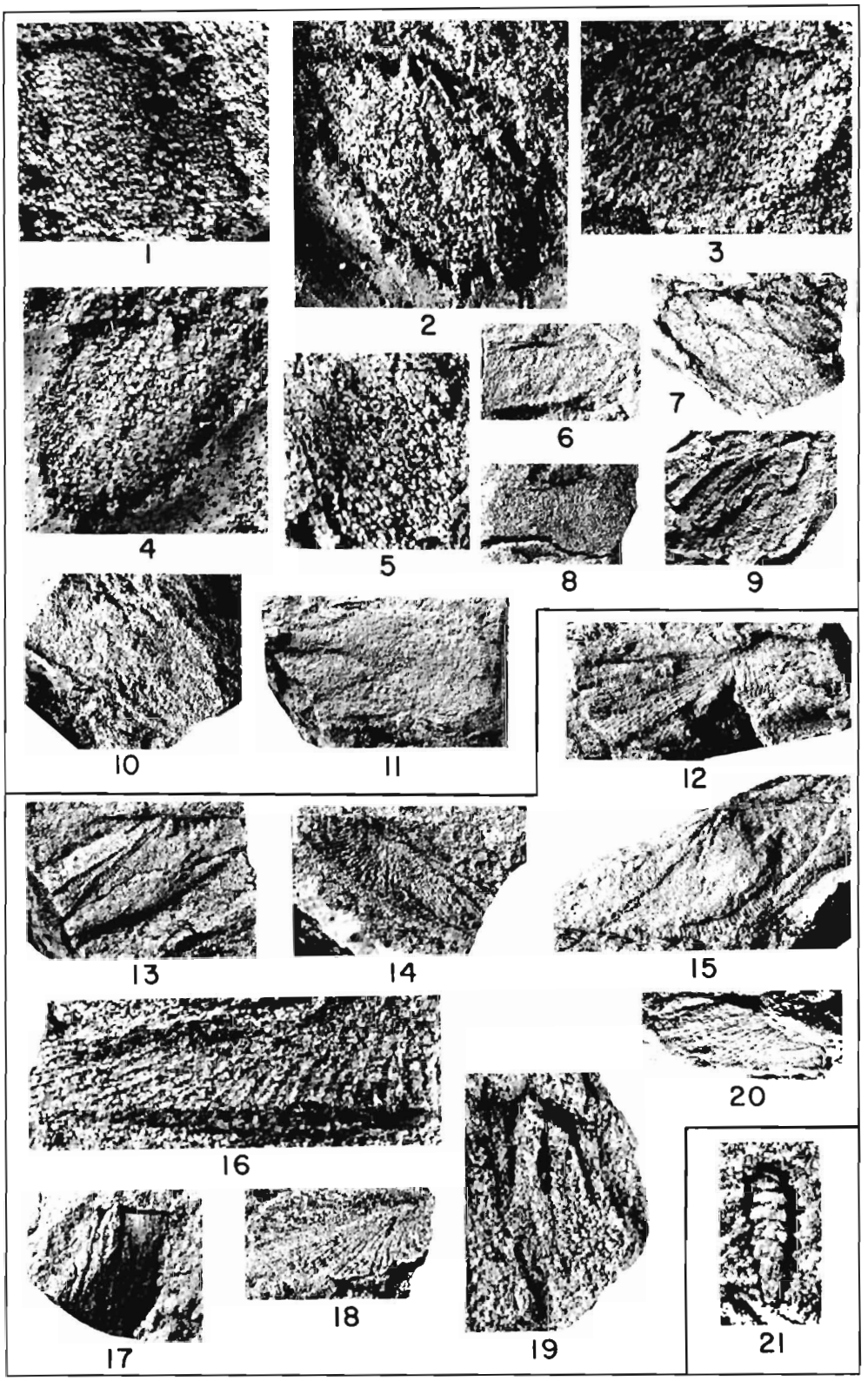
15–17. *Leptostrophia*? sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

15. Impression of pedicle interior (× 2) showing absence of dental lamellae, posteriorly projecting muscle field (counterpart of Fig. 16); USNM No. 140070
16. Impression of pedicle exterior (× 2) showing gentle convexity of valve, absence of radial ornamentation (counterpart of Fig. 15); USNM No. 140071
17. Impression of pedicle interior (× 2) showing impression of hinge teeth (counterpart of Pl. 8, fig. 1); USNM No. 140073



SILURIAN BRACHIOPODS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 7
Geological Society of America Bulletin, volume 74



SILURIAN FOSSILS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 8
Geological Society of America Bulletin, volume 74

PLATE 8. SILURIAN FOSSILS, CLOUGH FORMATION, NEW HAMPSHIRE

Figures

1–11. *Leptostrophia*? sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

1. Impression of pedicle exterior (× 2) showing convexity of valve, absence of radial ornamentation (counterpart of Pl. 7, fig. 17); USNM No. 140072
2. Impression of pedicle interior (× 2) showing position of muscle field, hinge teeth (counterpart of Fig. 3); USNM No. 140074
3. Impression of pedicle exterior (× 2) showing absence of radial ornamentation (counterpart of Fig. 2); USNM No. 140075
4. Impression of pedicle interior (× 2) showing posterior form of muscle field (counterpart of Fig. 5); USNM No. 140076
5. Impression of pedicle exterior (× 2) showing absence of radial ornamentation (counterpart of Fig. 4); USNM No. 140077
6. Impression of brachial interior (× 1) showing two cardinal-process pits (counterpart of Fig. 8); USNM No. 140063
7. Impression of brachial interior (× 1) showing cardinal-process pits (counterpart of Fig. 9); USNM No. 140061
8. Impression of brachial exterior (× 1) showing flatness of shell, absence of radial ornamentation (counterpart of Fig. 6); USNM No. 140064
9. Impression of brachial exterior (× 1) showing absence of preserved radial ornamentation (counterpart of Fig. 7); USNM No. 140062
10. Impression of brachial interior (× 1) showing impression of two cardinal-process lobes, weakly impressed muscle field (counterpart of Fig. 11); USNM No. 140057
11. Impression of brachial exterior (× 1) showing absence of preserved radial ornamentation, flatness of valve (counterpart of Fig. 10); USNM No. 140058

12–20. *Mesodouvillina* sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont

12. Impression of exterior (× 1) showing radial ornamentation; USNM No. 140067
13. Impression of pedicle interior (× 1) showing impression of hinge tooth tracks, form of muscle field, gentle convexity of valve (counterpart of Fig. 14); USNM No. 140055
14. Impression of pedicle exterior (× 1) showing radial costellae considerably modified by shearing (counterpart of Fig. 13); USNM No. 140056
15. Impression of pedicle interior (× 1) showing stout muscle-bounding ridges, anteriorly crenulated periphery; USNM No. 140068
16. Impression of exterior (× 2) showing radial ornamentation; USNM No. 140065
17. Impression of pedicle interior (× 1) showing impression of muscle-bounding ridges, form of muscle field; USNM No. 140059
18. Impression of exterior (× 1) showing form of radial ornamentation; USNM No. 140060
19. Impression of pedicle interior (× 2) showing impression of muscle-bounding ridges; USNM No. 140069
20. Impression of exterior (× 1) showing radial ornamentation, fine and relatively coarse costellae; USNM No. 140066

21. *Cornulites* sp. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont. Impression (× 3) showing annular ridges; USNM No. 140083

PLATE 9. SILURIAN FOSSILS, FITCH, CLOUGH, AND SHAW MOUNTAIN FORMATIONS, NEW HAMPSHIRE AND VERMONT

Figures

1–2. *Amphistrophia* cf. *A. funiculata* (McCoy, 1846). Fitch Formation; Fitch Farm, near Littleton, N. H. (locality 3 of Billings and Cleaves, 1934, p. 417)

1. Impression of brachial exterior (× 3); MCZ No. 8660
2. Impression of pedicle exterior (× 2) showing geniculate form, radial ornamentation. This is the specimen illustrated by Billings and Cleaves (1934, Pl. 2, fig. 10). MCZ No. 8660

3–4. Trilobite fragments. Upper part of Clough Formation; Beaver and Hetty brooks, Croydon Township, near Claremont, N. H.

3. Impression of thoracic segment (× 3); Beaver Brook; USNM No. 140084
4. Impression of exterior of encrinurid pygidium (× 3); Hetty Brook; USNM No. 140085

5–6, 13–18. *Paleocyclus* cf. *P. porpita* (Linnaeus, 1767). Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont, N. H.

5. Impression of septae (× 2); note nature of contact between fossiliferous weathered and unweathered rock; the crystalline, unweathered rock gives no indication of its fossiliferous nature; USNM No. 140087
6. Impression of septae (× 3); USNM No. 140087
13. Impression of septae (× 3); USNM No. 141442
14. Rubber cast, top view (× 3); USNM No. 141442
15. Rubber cast, side view (× 3); USNM No. 141442
16. Impression of septae (× 2); USNM No. 141443
17. Impression of septae (× 2); USNM No. 141444
18. Impression of septae (× 2); USNM No. 141445

7. Unidentified gastropod. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont, N. H. Filling of umbilicus (× 3) showing open nature of umbilicus and fine growth lines; USNM No. 140086

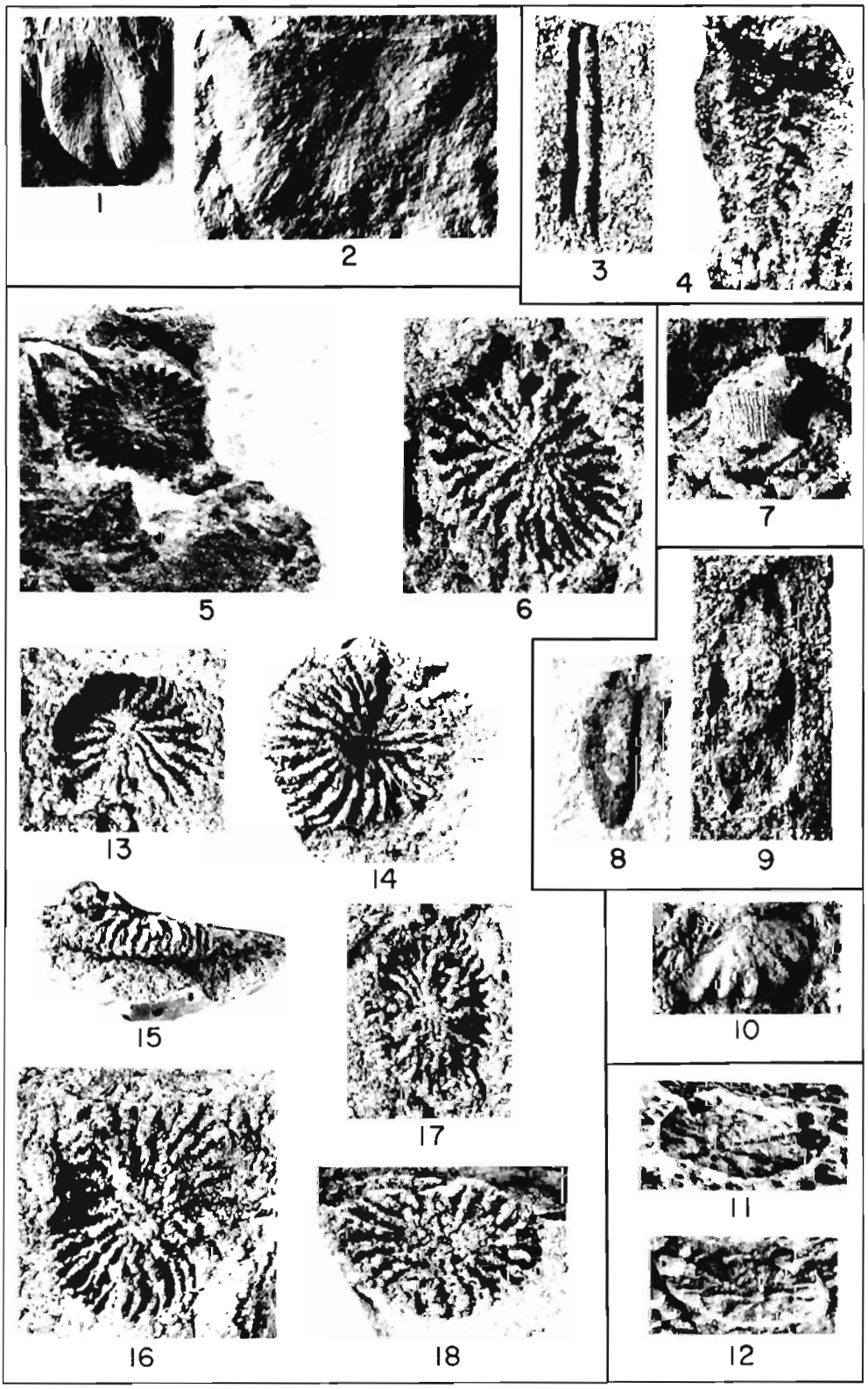
8–9. Pelmatozoan columnals. Upper part of Clough Formation; Beaver Brook, Croydon Township, near Claremont, N. H.

8. Impression of pelmatozoan columnal (× 2); note amount of deformation (counterpart of Fig. 9); USNM No. 140081
9. Impression of pelmatozoan columnal (× 3); note amount of deformation (counterpart of Fig. 8); USNM No. 140082

10. *Howellella* sp. Shaw Mountain Formation; 2 miles S. 37° W. of center of Albany Village, Hardwick quadrangle, Vt. Exterior of pedicle valve (× 3) showing strong, rounded plications and interspaces; U. S. Geological Survey No. SD-5610

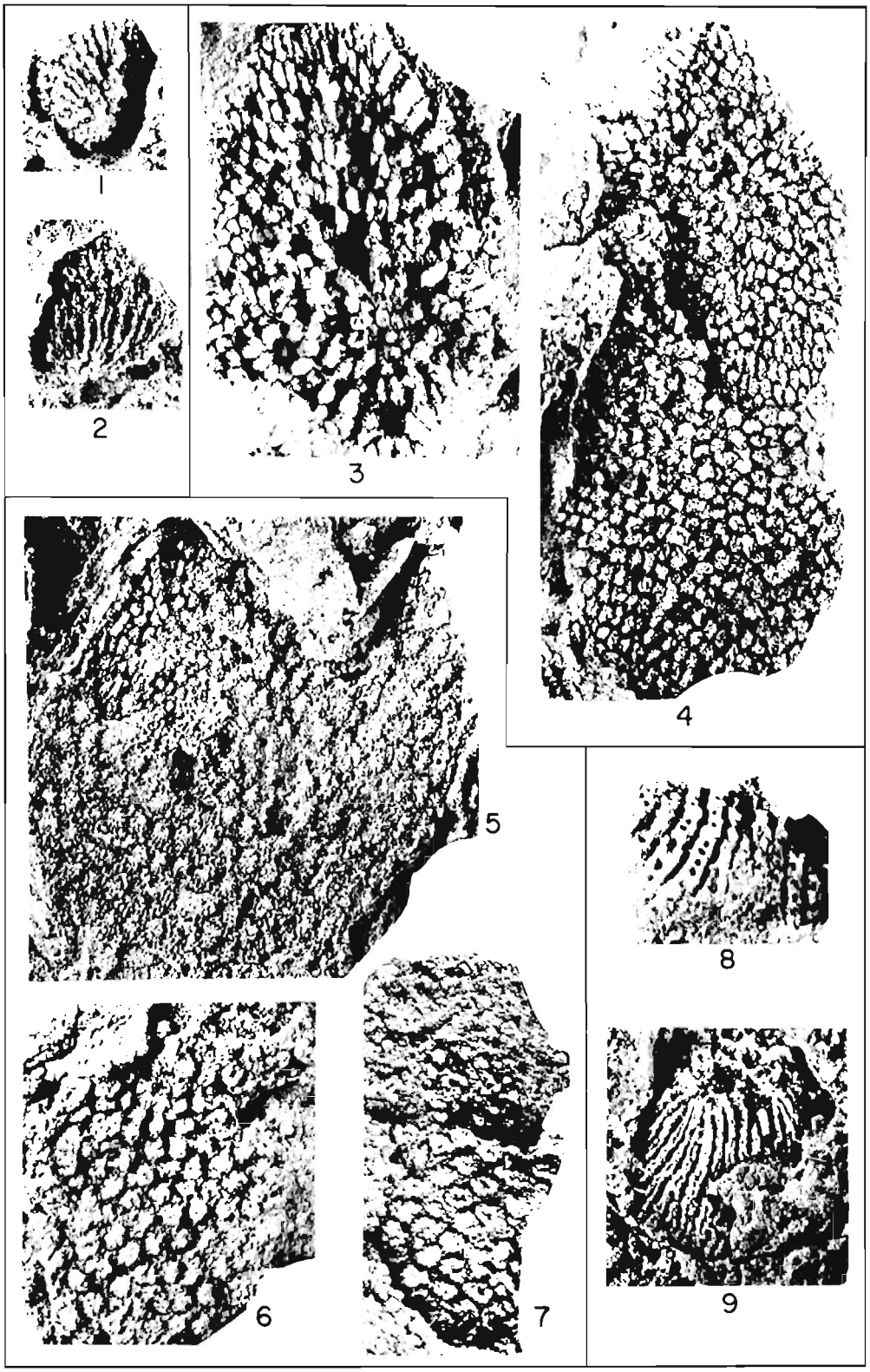
11–12. Pelmatozoan plate. Fitch Formation; loose boulder in Hetty Brook upstream from Clough exposures, Croydon Township, near Claremont, N. H.

11. Impression of exterior of pelmatozoan plate. Prof. G. Regnell reports (1962, written communication) "In addition to impressions of columnals, the specimen contains an impression of a plate. It can be said, of course, that this may or may not represent *Caryocrinites ornatus* Say, but nothing is gained by this, because the 'determination' would be entirely hazardous taking into account the preservation of the fossil." USNM No. 140082A
12. Gutta-percha replica of exterior of pelmatozoan plate. Same specimen as Figure 11



SILURIAN FOSSILS, FITCH, CLOUGH, AND SHAW MOUNTAIN FORMATIONS, NEW HAMPSHIRE AND VERMONT

BOUCOT AND THOMPSON, PLATE 9
Geological Society of America Bulletin, volume 74



SILURIAN CORALS, CLOUGH FORMATION, NEW HAMPSHIRE

BOUCOT AND THOMPSON, PLATE 10
Geological Society of America Bulletin, volume 74

PLATE 10. SILURIAN CORALS, CLOUGH FORMATION, NEW HAMPSHIRE

Figures

1–2. Horn corals. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont
1. Calice mold (× 2); USNM No. 141448
2. Side and bottom view of calice mold (× 2); USNM No. 141448

3–4. Favositid coral. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont
3. Impression (× 2); USNM No. 141453
4. Impression (× 2); USNM No. 141452

5–7. Heliolitid coral. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont
5. Impression (× 2); USNM No. 141450
6. Impression (× 2); USNM No. 141449
7. Impression (× 2); USNM No. 141451

8–9. *Tryplasma*? sp. Upper part of Clough Formation; Hetty Brook, Croydon Township, near Claremont
8. Impression of calice (× 3); USNM No. 141446
9. Impression of calice (× 2); USNM No. 141447